

Attorney's Docket No.: 12967-002001  
Client's Ref. No.: 997047-06 (TM/it)

**OFFICIAL COMMUNICATION****FACSIMILE****FOR THE PERSONAL ATTENTION OF:****EXAMINER Robert Kunemund****Group 1765 fax no: (703) 872-9439****Number of pages including this page 17**

Applicant : Tomohiro Kawase et al  
Serial No. : 09/824,965  
Filed : April 3, 2001

Art Unit : 1765  
Examiner : Robert Kunemund

**FACSIMILE COMMUNICATION**

Title : Method Of Preparing Group III-V Compound Semiconductor Crystal

Commissioner for Patents  
Washington, D.C. 20231

Sir:

We enclose for filing the following documents:

Response To Protest of Charles W. Bradley

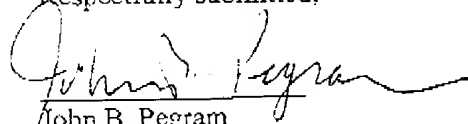
Information Disclosure Statement, PTO Form 1449 and 1 Reference (4 pp.)

faxed this 25th day of October, 2002, to Group 1765, the United States Patent and Trademark  
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Please charge our deposit account 06-1050 for the IDS fee, in accordance with the  
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Date: October 25, 2002

Respectfully submitted,

  
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cc: Charles W. Bradley, Esq. (by Facsimile)

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## IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : Tomohiro Kawase et al

Art Unit : 1765

Serial No. : 09/824,965

Examiner : Robert Kunemund

Filed : April 3, 2001

**Application for Reissue of:**

Patent No. : 6,007,622

Issue Date : December 28, 1999

Serial No. : 08/843,124

Filed : April 25, 1997

Title : METHOD OF PREPARING GROUP III-V COMPOUND SEMICONDUCTOR  
CRYSTALCommissioner for Patents  
Washington, D.C. 20231**RESPONSE TO PROTEST  
OF CHARLES W. BRADLEY**

Reissue applicant hereby responds to the Protest Under 37 C.F.R. 1.291 filed by Charles W. Bradley on or about September 24, 2002.

We recognize Mr. Bradley and Mr. Molano, who filed an earlier Protest, as attorneys who have represented AXT, Inc. in dealings with the reissue applicant concerning the subject of this reissue application, AXT's infringement of the original U.S. Patent No. 6,007,622 and the proposed interference with AXT's U.S. Patent No. 6,045,767.

## CERTIFICATE OF TRANSMISSION BY FACSIMILE

I hereby certify that this correspondence is being transmitted by facsimile to the Patent and Trademark Office on the date indicated below.

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## 1. Summary of Protest and Response

The Bradley Protest contends that the Marshall-DeCuir Article<sup>1</sup> anticipates independent claim 1 and dependent claims 2, 4, 6, 9, 13 and 18-22 of the reissue application, all of which are original claims of the '622 patent.

The Bradley Protest does not assert any other grounds of unpatentability of those claims. In particular, the Bradley Protest does not assert that the Marshall-DeCuir article, either alone or in combination with other references, teaches or suggests the claimed inventions; and the Bradley Protest does not address the objective factors relating to a determination of obviousness. *See, e.g., Trintec Ind., Inc. v. Top-U.S.A. Corp.*, 295 F.3d 1292, 1297, 63 USPQ2d 1597, 1601 (Fed. Cir. 2002) ("Obviousness involves, for instance, questions of suggestions to combine, ... and objective indicators of patentability.").

The Bradley Protest does not assert unpatentability on any grounds with respect to any other claims of the reissue.

As we will show, Marshall-DeCuir does not disclose, teach or suggest the claimed inventions. In particular, and without limitation, claim 1 is distinguished from Marshall-DeCuir's LEC process by the limitations requiring "solidifying said melted compound raw material [which is "in said crucible or boat"] to grow a carbon-doped compound semiconductor crystal" and "placing ... solid carbon ... into a crucible or boat" ... "wherein an amount of said solid carbon placed into said crucible or boat is larger than an amount of carbon doped into said compound semiconductor crystal."

## 2. The Law of Anticipation

A rejection on grounds of anticipation requires a showing that each and every element as set forth in the claim must be found, either expressly or inherently described, in a single prior art reference. *See Bristol-Meyers Squibb Co. Ben Venue Labs., Inc.*, 246 F.3d 1368, 1374, 58 USPQ2d 1508, 1512 (Fed. Cir. 2001); MPEP § 2131. "The identical invention must be shown in as complete detail as is contained in the ... claim." MPEP § 2131 quoting *Richardson v. Suzuki*

<sup>1</sup> Marshall & DeCuir, "A novel technique to reduce the concentration of carbon in LEC gallium arsenide," *Journal of Crystal Growth*, Vol. 110 (1991) 960-962.

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*Motor Co.*, 868 F.2d 1226, 1236, 9 USPQ2d 1913, 1920 (Fed. Cir. 1989). Because of this "strict identity requirement," cases involving anticipation are "quite rare." *Trintec Ind.*, *supra*, 295 F.3d at 1297, 63 USPQ2d at 1601.

Further, the reference must describe the claimed invention sufficiently to have placed a person of ordinary skill in the art in possession of it. *See, e.g., Rowe v. Dror*, 112 F.2d 473, 480-81, 42 USPQ2d 1550, 1555 (Fed. Cir. 1997) (not enough if artisan must guess).

### 3. The Marshall-DeCuir Article

As explained in its title and abstract, the principal subject of the Marshall-DeCuir article is the reduction of carbon concentration in GaAs crystals.

The first paragraph of this article discusses various factors affecting carbon concentration in GaAs crystals. Among them is the carbon contribution of graphite parts within the crystal-growing enclosure. (*See* section 3.1 below.)

It also is apparent from the article's title, the phrase "molten prior to seeding" at line 9 of the first paragraph and the use of boric oxide ( $B_2O_3$ ) that a Liquid Encapsulated Czochralski ("LEC") process is being discussed.

Persons skilled in the art understand that in a Czochralski process, a solid seed crystal is lowered into contact with the top surface of molten raw material and then is pulled slowly upward, forming a solid crystal boule. *See, e.g., Parsey*, "Relative virtues of different bulk growth techniques," p. 406, Fig. 2 (Reference AQ). *See also* Yamashita, U.S. Patent No. 5,515,810, Fig. 1 (a reference in the original '622 patent). Persons skilled in the art also understand that in the LEC process an inert sealant—such as boric oxide—is used to cover the upper surface of the molten raw material. Boric oxide may also be retained on the surface of the boule as it is pulled. *See Parsey*, pp. 407-408; Yamashita, Fig. 1 and col. 6, lines 39-45; Marshall-DeCuir, Fig. 1.

The Marshall-DeCuir article discusses four test crystals A-D, which the article states were produced using Czochralski pullers using the same process except for stated differences.

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Crystals A and B were apparently made using Marshall-DeCuir's "standard production process." According to Table 1 and Fig. 2, their carbon concentration was in the range of 25 to  $50 \times 10^{14}$  atoms/cm<sup>3</sup>. The source of that carbon is not specified. (See section 3.1 below.)

The Marshall-DeCuir article describes its principal object, the production of crystal C with reduced carbon content as a result of injecting the melt with As<sub>2</sub>O<sub>3</sub>, apparently using material from crystal A or B or both as the raw material.

The resulting crystal C, however, apparently had a lower than desired carbon content. "To restore these properties, crystal C was carbon doped and regrown." (p. 962, col. 1, lines 17-19) The result, as shown in Table 1, was crystal D, with a carbon concentration of 33 to 37 x 10<sup>14</sup> atoms/cm<sup>3</sup>. That concentration is not significantly different from that of crystals A and B, and the authors' standard production. (See Table 1 and Fig. 2)

The Marshall-DeCuir article does not clearly disclose the source of the carbon in crystal D that is in excess of that in the starting material, crystal C. Mr. Bradley's Protest points to the Marshall-DeCuir article's "vigorously rubbing 0.0012 g. of 99.99% carbon fiber into the inside bottom of the PBN crucible prior to loading with GaAs" (page 962, col. 1, lines 19-22). As we point out in the next section, however, persons skilled in the art would not have been likely to attribute the resulting carbon concentration to that.

### **3.1 Persons Skilled in the Art Would Understand That the Carbon Source Was Conventional**

The Bradley Protest overstates the disclosure of the Marshall-DeCuir article. Contrary to the statement at page 3, lines 10-12 of the Bradley Protest, the Marshall-DeCuir article does not concern "adding carbon in a controlled fashion, in order to control the amount of carbon and consequently the amount and distribution of the carbon in the resulting GaAs ingot...." (emphasis added) No such control is disclosed.

The first paragraph of the Marshall-DeCuir article discusses various factors affecting carbon concentration in GaAs crystals and admits the authors' lack of a clear understanding of the sources of carbon. Among potential carbon sources noted are graphite parts within the crystal-growing environment. In Fig. 1, the article shows a heater within the furnace chamber.

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Typically, such heaters include graphite that contributes to the carbon concentration in the resulting crystal, as acknowledged in the article. At the time of this article, the graphite elements within a LEC pull chamber were recognized as the major source of carbon in the resulting GaAs boule. *See, e.g.,* Yamashita, col. 3, lines 13-15, 25-30; Doering et al, (Reference AR) (referring to the graphite heater and heat shields as a carbon source in an LEC process).

Doering et al cites another article discussing carbon doping, Nishio & Terashima, "Influence of Melt Preparation on Residual Concentration in Semi-Insulating LEC GaAs." *Journal of Crystal Growth*, vol. 96 (1989) 605-608 (Reference AY, submitted herewith). That article indicates that—given sufficient time—an equilibrium-like balance is achieved in the LEC process between the carbon incorporation and extraction mechanisms.

Persons skilled in the art reading the Marshall-DeCuir article would understand that the heater and other graphite in the furnace enclosure would be a source of carbon in producing crystal D to the same extent as in producing crystals A and B, and in the authors' standard process. Since the resulting carbon concentrations are in the same range for all of crystals A, B and D, persons skilled in the art would attribute the carbon doping of those crystals to the graphite within the furnace enclosure and to the establishment of a carbon equilibrium fed by those sources. Skilled persons would discount the alleged contribution to crystal D of the carbon rubbed into the bottom of the crucible because it produces no significant difference from crystals A and B, and for many other reasons. The actual amount of that carbon in the melt and the relationship between that carbon amount and GaAs is undisclosed. In particular, did any of the carbon become bound to the crucible and what happened to any remaining free carbon? To what degree was the carbon oxidized to CO gas by heating of the crucible before melting of B<sub>2</sub>O<sub>3</sub> or of the GaAs? Marshall-DeCuir lacks any pertinent teaching or analysis. The description of "vigorously rubbing ... into the inside bottom" suggests that free carbon particles were not desired and that the objective was to simulate a carbon-containing crucible. The disposition of any carbon particles which were not "rubbed into" the crucible is undisclosed. If the intent was to bind carbon to the crucible, the excess, free particles probably were dumped out. Also, the article lacks any disclosure of the amount of carbon "rubbed into" the crucible which remained in the crucible following crystal pulling.

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Further, the Bradley Protest errs in two other respects where it attributes the carbon concentration uniformity of crystal D to carbon rubbed into the crucible. (Protest, page 4, lines 8-9) First, persons skilled in the art would expect a smaller range of variation in carbon concentration of crystal D as compared with crystals A and B, because shorter crystals typically have less variation. The smaller quantity of material in crystal D, results in a shorter crystal as compared with the crystals A, B and C. (At each stage, two slices were removed for testing, and a residue would have been left in the crucible.) Second, Marshall-DeCuir lacks a sufficient number of samples for scientific analysis.

#### **4. Lack of Anticipation of Claim 1 and All Dependent Claims**

Claim 1 of the present reissue application is not anticipated by the Marshall-DeCuir article under the applicable legal standards (*see* section 2 above) for two principal reasons, discussed below.

##### **4.1 The Article Does Not Disclose "solidifying ... to grow"**

Claim 1 is limited to a method comprising "solidifying said melted compound raw material [which is "in said crucible or boat"] to grow a carbon-doped compound semiconductor crystal." This limitation relates, for example, to the disclosures in our substitute specification at p. 4, lines 21-29; p. 10, line 30 – p. 11, line 5 and p. 12, line 30 – p. 13, line 8; and should be interpreted in the light of those disclosures. This limitation distinguishes the claim from the Marshall-DeCuir process.

The Marshall-DeCuir article does not disclose such "solidifying ... to grow." Its Czochralski-type crystal formation maintains the compound raw material in the crucible in a melted condition and pulls melted material from the crucible to form a crystal outside the crucible.

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#### **4.2 The Article Does Not Disclose a Relationship Between Carbon Placed in a Crucible and the Resulting Crystal**

Claim 1 is limited to a method of growing a carbon-doped crystal comprising "placing ... solid carbon ... into a crucible or boat" and "wherein an amount of said solid carbon placed into said crucible or boat is larger than an amount of carbon doped into said compound semiconductor crystal."

The Marshall-DeCuir article does not disclose, teach or suggest any relationship between solid carbon placed into a crucible or boat, and the amount of carbon doped into the resulting crystal. As discussed in section 3.1 above, the article discloses rubbing a quantity of carbon fiber into the bottom of the crucible, but does not disclose whether all of the carbon was held in the crucible's pores or the disposition of any excess. Although Mr. Bradley calculates that the carbon in the resulting crystal is less than the amount used for rubbing, there is no disclosure in the article of the relationship and no disclosure that the Bradley Protest's calculation should be made. The reference did not describe the claimed invention sufficiently to have placed a person of ordinary skill in the art in possession of it, as required by the law of anticipation. *See, e.g., Rowe v. Dror, supra.*

The Bradley Protest's contention that the article anticipates this claim limitation is wrongly based on hindsight, employing the teaching of the '622 patent.

#### **5. Non-Anticipation of Dependent Claims 2, 4, 6, 9, 13 and 18-22**

None of dependent claims 2, 4, 6, 9, 13 and 18-22 are anticipated for each of the reasons stated above with respect to claim 1.

##### **5.1 Additional Distinction in Claims 2 and 20**

Dependent claims 2 and 20 each include a limitation that the melted boron oxide substance is in contact with at least a portion of the solid carbon during the step of heating and melting the compound raw material.

This requirement is not disclosed, taught or suggested in the Marshall-DeCuir article.



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The only disclosure in the Marshall-DeCuir article regarding boron oxide is the statement concerning crystal growth in the Czochralski process, "wet boric oxide (1200 ppmw) was used as the encapsulant." (p. 962, col. 2, lines 26-27) There was no disclosure of the quantity used or of boron oxide contacting any carbon.

As discussed in section 3 above, persons skilled in the art would understand from this disclosure that sufficient boric (boron) oxide would be used to float on top of the raw material sealing the top surface of the crucible, particularly adjacent the area where the crystal is pulled from the melt. That is the only place  $B_2O_3$  is shown in Marshall-DeCuir's Fig. 1.

Persons skilled in the art would understand the article's disclosure to be that the only carbon in the crucible is remote from the boron oxide, rubbed into the bottom of the crucible.

In addition, the first paragraph of the article points out that "Increasing water content in the boric oxide encapsulant generally reduces carbon in LEC melts." From that disclosure and the disclosure of wet boric oxide, one skilled in the art would be lead away from permitting the wet boric oxide to contact carbon in order to increase carbon doping.

## 5.2 Additional Distinction in Claim 6

Claim 6 includes the limitation that the solid carbon placed into the crucible or boat is at least 10 times larger than the amount of carbon doped into the compound semiconductor crystal.

The Marshall-DeCuir article does not disclose, teach or suggest this "at least 10 times larger" requirement. Indeed, as discussed in Section 4.2 above, the article does not discuss any relationship between the amount of solid carbon placed in the crucible and the carbon concentration, nor does it disclose the amount of carbon actually placed in the crucible with the compound raw material and boric oxide.

The "at least ten times" requirement of claim 9 is not anticipated.

## 5.3 Additional Distinction in Claim 13

Claim 13 includes the limitation that the solid carbon, which is placed in the boat or crucible with the compound raw material and boron oxide, comprises fiber carbon.

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The Marshall-DeCuir article does not disclose, teach or suggest this limitation. Persons skilled in the art would understand that the "vigorously rubbing ... carbon fiber into the inside bottom of the PBN crucible prior to loading with GaAs." would destroy the fibrous characteristic of the carbon. Therefore, the limitation of claim 13 is not anticipated.

#### 5.4 Additional Distinction in Claim 21

As noted above, it is unclear whether the Bradley Protest is directed to claim 21. It is not referenced in the statement of protest on page 1, but is referenced in the "Index" and on page 4. It is not included in the dependent claim table at pages 7-8 and is not discussed in detail.

Claim 21 relates to "selecting a target amount" of carbon concentration and "adjusting" the solid carbon placed in the crucible or boat "so as to responsively achieve said target amount...."

The Marshall-DeCuir article does not disclose, teach or suggest the "selecting" or "adjusting" required by the limitations of claim 21. Indeed, as discussed above, the article does not disclose, teach or suggest any relationship of solid carbon-to-carbon concentration in the resulting crystal. Therefore the claim is not anticipated.

#### 5.5 Additional Distinction in Claim 22

As noted above, it is unclear whether the Bradley Protest is directed to claim 22. It is not referenced in the statement of protest on page 1, but is referenced in the "Index" and on page 4. It is not included in the dependent claim table at pages 7-8 and is not discussed in detail.

The limitation in claim 22 requires "a variation of carbon concentration of not more than 8-1/3% between a lowest carbon concentration and a highest carbon concentration, relative to said lowest carbon concentration."

The range of carbon concentration disclosed for "doped" crystal D of the Marshall-DeCuir article is:

Seed	$33 \times 10^{14}$ atoms/cm <sup>3</sup>
Tail	$37 \times 10^{14}$ atoms/cm <sup>3</sup>

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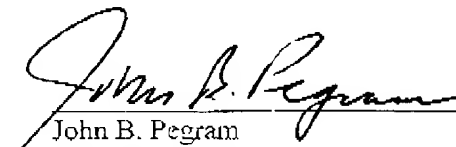
Persons skilled in the art would understand that "Seed" and "Tail" refer to the two ends of a crystal resulting from a Czochralski pulling process. They also would understand that the disclosed range is a variation of 12.12%, relative to the lowest carbon concentration. Therefore, the article does not anticipate claim 22.

#### 6. Conclusion

The Bradley Protest fails to show that each and every element as set forth in the claim is found in a single prior art reference and that the identical invention is disclosed by the cited reference in as complete detail as is contained in the claims. Further, the reference does not describe the claimed inventions of the protested claims sufficiently to have placed a person of ordinary skill in the art in possession of them. The protested claims should be allowed.

Respectfully submitted,

Date: November 25, 2002

  
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